production needed to support a healthy aquatic foodweb.

Changes in Delta channel hydraulics began in the mid-19th century with land reclamation that restricted flows to narrow channels defined with levees. These same channels later became conduits for carrying water to the water export facilities in the central and south Delta. In 1951, the CVP began to transport water from the south Delta to the Delta-Mendota Canal. Operation of the Delta Cross Channel in the north Delta began to allow Sacramento River water to flow through interior Delta channels from the north to the southern Delta export facilities. South Delta export facilities were increased with the addition of the SWP pumping plant in the late 1960s. Delta channel hydraulics in the June through September period were adversely affected by Delta diversions as early as the mid 1950s. In the 1960s, impacts extended into the April and May period. Delta channel hydraulics, particularly in the November through April period, were dramatically affected beginning in the early 1970s and continuing into the 1980s, a period of steep declines in the abundance of native fish species. In the San Joaquin Valley, Friant Dam delivered the entire flow of the upper San Joaquin River south, abruptly eliminating a major run of chinook salmon. The fish fauna of the rivers and Delta changed abruptly as well because resident non-native fishes were favored over native fishes, resident and anadromous. Thicktail chub and Sacramento perch gradually were driven to extinction in the system.

Existing Delta hydraulic conditions inhibit the ecological functions of the Delta as a migration corridor and rearing habitat for native species such as Chinook salmon and important non-natives such as striped bass. Native residents such as Delta smelt, which depend on natural hydraulic processes that help support spawning habitat and a productive foodweb, have been impacted by changed hydraulic conditions, particularly in the last two decades.

In the 1960s, the State Water Project went into operation with the completion of Oroville Dam on the Feather River (1967) and the construction of another set of big pumps in the south Delta. By this time, nearly every major river and creek feeding the Central Valley and the estuary was dammed. Not only was the water available for natural ecosystem processes increasingly diminished in amount, but it was increasingly polluted, the result of the ever-increasing urbanization of the region and more intensive agriculture.

Native resident and anadromous fishes continued to decline, as did the native flora and fauna of riparian areas and wetlands as water diversions increased and as wetland and riparian habitats continued to be diminished. (In dry years, migratory waterfowl were largely confined to artificial wetlands and showed marked downward trends as well.)

POLLUTION. Industrial, municipal, and agricultural wastes have been discharged into waters of the Bay-Delta system, with major historical point sources including wastes from fish and fruit/vegetable canneries and municipal sewage. The large-scale pollution of the estuary and rivers was partially relieved by the passage of the Clean Water Act, resulting in the construction of sewage treatment plants in all cities. Mines such as the Penn Mine on the Mokelumne River and the Iron Mountain Mine on the Sacramento River continue as serious sources of contaminants, with some releases from Shasta Dam made explicitly to dilute Iron Mountain leachate below lethal levels in the river to avoid fish kills. Nonpoint sources of pollution, such as urban runoff and agricultural runoff, continue to impair water quality. Agricultural drainage (often highest in summer from irrigation return flow) typically has elevated temperatures and contains excessive loads of constituents such as organic carbon, nitrates, phosphates, as well as herbicides and pesticides toxic to phytoplankton, invertebrates, and larval fish (Bailey et al. 1995).

INTRODUCTION OF NON-NATIVE SPECIES. As the native fishes became depleted in the late 19th century, non-native species were brought in (especially following the completion of the transcontinental railroad in 1872): American shad, striped bass, common carp, and white catfish. As their populations boomed, those of native fishes declined further. Introduction of non-native species accelerated in the 20th century through deliberate introductions of fish and unintended introductions of harmful invertebrates and fish,

mainly through ballast water of ships. Establishment of non-native species was probably facilitated by altered hydrologic regimes and reduction in habitats suitable for native species.

Non-native birds have also adversely affected native bird species populations through competition, predation, and other means.

CHANGES IN POPULATIONS OF NATIVE SPECIES RESULTING FROM HUMAN ALTERATION TO THE ECOSYSTEM

Populations of a number of species have declined sufficiently since the 19th century to warrant their listing under the federal Endangered Species Act of 1973. Twenty-one species of plants, seven species of invertebrates, four fish species, one amphibian species, one reptile species, six bird species, and one mammal species present in the Bay and Delta region alone that are listed as threatened or endangered, with a number of others proposed for listing or listed under the equivalent state law. Perhaps the most significant of these listings have been those for winter-run chinook salmon, delta smelt, and steelhead trout because their recovery is likely only if there is a significant reallocation of water for environmental purposes, as well as significant improvements in their remaining habitats.

PRESENT CONDITIONS AND TRENDS

PRESENT CONDITIONS

The status of the ecosystem is described in detail in the affected environment chapters of the Fisheries and Aquatic Ecosystems Technical Appendix and Vegetation and Wildlife Technical Appendix to the CALFED Programmatic EIS/EIR.

ENVIRONMENTAL TRENDS. Specific currently discernable environmental trends are likely to continue during the next few decades. These trends would largely result in continued environmental degradation, although some positive trends are also apparent. Population growth will lead to an increase in the demands on water and other resources in California (e.g., gravel, petroleum, and wood products). Other possible sources of increased environmental degradation include conversion of agricultural lands to urban land uses, a likely shift in agricultural practices to more intensive crops, flood control activities, new introductions and expansion of non-native species, sea-level rise, and global climate change. On the positive side, several legislative and policy initiatives could result in improvements in habitat and water quality.

These trends in the demand for natural resources present constraints and opportunities on the extent to which CALFED can successfully rehabilitate elements of ecosystems that are critical to achieving the goals and objectives of the ERP (e.g., recovery of endangered species and maintenance of populations of other native species at levels sufficient to prevent potential future listings of species). The effect of these trends (along with the current commitment of land and natural resources to other uses) is to necessarily preclude wholesale rehabilitation of the ecosystem to a semblance of its historical condition. Instead, these trends will most likely limit CALFED to successful rehabilitation of representative "islands" within the Bay-Delta system in which most or all of the ecological processes associated with the historical ecosystem have been restored and to partial rehabilitation of some attributes historically associated with the ecosystem throughout the Bay-Delta system.

TRENDS IN POPULATION AND WATER USAGE. The California Department of Finance projects California's population to grow from its 1995 level of 32.1 million to 47.5 million in 2020, an increase of approximately 48%. Irrigated crop acreage is expected to decrease slightly from 9.5 million acres to 9.2 million acres. These factors (as well as changes in use rates) are expected to lead to a slight decrease in agricultural water use (from 33.8 MAF to 31.5 MAF), but significant increases in urban water uses over the same period (from 8.8 MAF to 12.0 MAF). These numbers are estimates from DWR's State Water Plan Update (California Department of Water Resources 1997) and are subject to different assumptions regarding the size and effectiveness of water conservation programs.

Increasing demand on water for urban uses will lead to increasing competition for water between agricultural, urban, and environmental uses,

particularly during drought periods. Additionally, because the greatest population increases are projected to occur in southern California, an area dependent on water exported from the Delta, there is the potential to intensify the environmental impacts created by the existing water supply system. Population increases may also intensify environmental degradation through increased urbanization (conversion of natural and agricultural lands to urban uses) and increased demand for resources (such as sand and gravels, petroleum, wood products and other construction materials).

In view of this, attempts to restore the ecosystem in the future or increase the extent of natural habitats in the Bay-Delta system that are dependent on fresh water, including the physical processes associated with its flow, is likely to be more difficult than under current circumstances. Recognition that the availability of water for all uses is ultimately limited underscores the necessity of the ERP to focus the use of environmental water on rehabilitation of sufficient portions of the Bay-Delta system that are critical to meeting the goals and objectives of the ERP. Recognition of this trend also underscores the necessity for the ERP to secure sufficient environmental water in balance with other uses sooner, rather than later, to ensure success of the ERP.

CHANGES IN AGRICULTURAL CROPPING PATTERNS. Agricultural cropping patterns are expected to shift away from field and forage crops to higher intensity crops, such as vegetables, vineyards, and orchards, which typically provide less wildlife habitat for listed species such as the Swainson's hawk and greater sandhill crane. Because these more intensively managed crops are more profitable, agricultural land is expected to become more expensive and difficult to purchase for habitat restoration. These trends will place greater demands on remaining and restored native habitats to support displaced wildlife populations and constrain the quantity and location of habitat that can be restored.

INCREASES IN FLOOD PROTECTION. Periodic flooding is an important river function that sustains ecological functions by creating a matrix of diverse habitats, by replenishing nutrients in the system, and by transporting sediments and biota through the system. Plans for increased flood protection could lead to greater constraints on ecological structure and functions.

Increased flood protection can directly affect ecological functions by decreasing habitat diversity; creating barriers to the movement of sediment, nutrients, and species; removing riparian habitat; and reducing or eliminating floodplain inundation. Indirect impacts can also result. As the perceived threat of flooding is reduced, more floodplain lands are subject to urban and agricultural development. The increasing demand for flood control increases the urgency to provide innovative flood management solutions that increase the flood conveyance capacity of the rivers by restoring meander belts and enlarging the floodplain area.

NON-NATIVE SPECIES. As discussed elsewhere in this strategic plan, the introduction and spread of non-native species into the Bay-Delta system has affected native species by competing with them for food and habitat, preying on native species, and interfering with restoration efforts. For example, the non-native mitten crab can clog fish screens, reducing their effectiveness or completely blocking flows. In spite of efforts to address this problem, it is likely that new species will continue to be introduced into the ecosystem and that non-native species introduced in the past will continue to expand their range.

GLOBAL CLIMATE CHANGE AND SEA-LEVEL RISE. In spite of expectations of more extreme weather patterns, sea-level rise, and the potential for these changes to affect the structure and functioning of the ecosystem, the rate and nature of global climate change are still too poorly understood to be explicitly considered in this document, but as such information improves, it should accounted for in decision making under the adaptive management framework.

IMPORTANT LEGISLATIVE ACTIONS AFFECTING ENVIRONMENTAL TRENDS

Although the pressures created by increasing population and urbanization, by changes in agricultural cropping patterns, and the introduction and spread of non-native species will most likely continue to exert negative forces on the environment and on ecological processes in the

Bay-Delta system, several recent and important legislative actions have been initiated that will serve to moderate potential effects of these adverse trends.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT. The Central Valley Project Improvement Act (CVPIA) is a federal law passed in 1992 that adds the maintenance of fish and wildlife to the list of objectives of the Central Valley Project (CVP). CVPIA provides resource managers with a large number of tools to aid in the recovery of fish and wildlife species, including the dedication of water to instream flows and Delta outflow, the creation of a fund to pay for further water purchases for habitat restoration, the allocation of CVP water supply to improve the reliability of deliveries to wildlife refuges, the retirement of agricultural lands to improve water quality, and the creation of a program to provide incentives for farmers to maintain habitat values on their lands. Among the goals of CVPIA is to double the population of naturally reproducing target fish species. Although it is not yet clear whether the tools provided by CVPIA will lead to the achievement of this goal or how the various provisions of it will ultimately be implemented, it is very likely that implementation will lead to improvement in habitat conditions for many fish and wildlife species.

1995 WATER QUALITY CONTROL PLAN. In 1995, the SWRCB adopted a water quality control plan for the Bay-Delta that includes rules governing Delta exports and Delta outflows. This plan intended to maintain salinity in the Delta at levels needed to maintain the health of the ecosystem. Since 1995, it has been the responsibility of CVP and the State Water Project (SWP) to comply with these rules, but SWRCB is now holding hearings to decide how the responsibility for compliance should be allocated among all water users in the Bay-Delta system. The results of these hearings will most likely lead to increases in instream flows in most, if not all, of the tributaries to the Delta. This change would improve conditions for fish and other aquatic species in those tributaries.

SACRAMENTO AND SAN JOAQUIN RIVER BASINS COMPREHENSIVE STUDY. The Comprehensive Study is being conducted by the U.S. Army Corps of Engineers and the California Reclamation Board with support from Department of Water Resources' staff and in cooperation with numerous other agencies and organizations. The study will cover a four-year period with Phase I being completed by April 1999. The study will initially identify problems, opportunities, planning objectives, constraints and measures to address flooding and ecosystem problems in the study area. It will ultimately develop a strategy for flood damage reduction and integrated ecosystem restoration along with identification of projects for early implementation. Solutions will include consideration of both structural and non-structural measures. The study objectives are expected to lead to innovative solutions to flooding and environmental problems in the Central Valley.

The Comprehensive Study reflects evolving policy at both state and federal agencies regarding the environment. Agencies that historically focused exclusively on improving flood protection are now incorporating the maintenance or enhancement of environmental values into their missions. This change in approach will most likely lead to more environmentally friendly solutions to water supply and flood control problems.

CLEANUP OF THE SOURCES OF TOXIC POLLUTANTS. The role of toxic pollutants in the decline of ecosystem functions in the Bay-Delta system is not yet well understood, but it is clear that these pollutants do contribute to morbidity and mortality in some aquatic species. Several efforts are currently underway under the EPA's Superfund program to clean up major sources of these pollutants. Although the solution to problems such as the Iron Mountain Mine will not easily be achieved, if successful, they could contribute considerably to restoring the health of the Bay-Delta system.

LAND USE PATTERNS AND TRENDS

The Bay-Delta system is undergoing major changes in land use and intensification (San Francisco Estuary Project 1992b). The San Francisco Bay itself and the central Delta are under the jurisdiction of the San Francisco Bay Conservation

and Development Commission (BCDC) and the Delta Protection Commission, respectively. Land use in the periphery of the Delta and in the lower watersheds are the prerogative of local governments, with the federal government (U.S. Forest Service, U.S. Bureau of Land Management, National Park Service) managing a larger proportion of the upper watersheds.

Urbanization of the periphery and immediate watersheds of San Francisco Bay are relatively stable, but other areas are undergoing rapid change, especially the watershed of Suisun Marsh, eastern Contra Costa County and the western Delta (residential subdivisions, "New Towns"); the south-Delta/lower San Joaquin River historical floodplain ("New Town" proposals); the east-Delta periphery (low-density residential, "New Towns," and very-low-density residential). Fairfield, Oakley, Brentwood, Tracy, Lathrop, Stockton, Lodi, Elk Grove, Sacramento, Winters, and other cities within the periphery of the Delta are experiencing strong growth pressures. Rural areas above the Delta and below dams are expanding, with both residential subdivisions (e.g., three to five dwelling units/acre), and very low-density residential development (e.g., five to 20 acres/dwelling unit). Land use is also changing in the lower-watershed/intertidal zone where sea-level rise and flooding are an issue.

Urbanization and concomitant increased motor vehicle use are a major contributor of contaminants (especially heavy metals). Residential development, even at very low densities, raises important land use considerations, including habitat fragmentation, loss of the use of fire as a vegetation management tool, and increased demand for flood protection.

Although CALFED's focus is on state and federal activities in ecosystem restoration, the program must be cognizant of land use issues that may help or hinder these activities and work with those responsible to encourage and support land use patterns that are compatible with ecosystem protection and restoration. Collaborative work in flood management, waterfront development, stream-corridor management, park and recreation design, and watershed management and planning will be especially important.